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Development of an exercise expert system for older adults

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Abstract—The purpose of this study was to develop a computerized exercise expert system (CEES) that creates tailored exercise plans for older adults. A panel of experts was selected in the areas of medicine, exercise physiology, health promotion, exercise psychology, and gerontology. The experts communicated with the principal investigator and the project members by mail, email, telephone, and expert meetings. A two-day workshop was held during the second year for the project members as well as local and national experts to review the CEES. The CEES demonstrated adequate inter-rater reliability (0.80) and criterion validity (0.70). Content validity was achieved by literature review and expert opinion. The CEES gathers information on the elder's health status, clinical factors, and exercise determinants that characterize specific barriers or incentives to exercise. The software program then develops individualized exercise prescriptions that are customized to older adults.

Keywords: *aging, computer technology, exercise.*

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INTRODUCTION

Although a majority of older adults recognize the importance of exercise, fewer than 23 percent of older males and 15 percent of older females in the United States report participation in regular, sustained exercise at 5 times a week for 30 or more minutes per session (1). This lack of exercise is frustrating considering the benefits that exercise can have, especially for older adults. Low participation by older adults may be due in part to the lack of availability of proper exercise programs for their age group (2). Patient and health care-provider interaction presents a potential opportunity for making a significant impact on the patient's exercise routine. In fact, 85 percent of adults stated that a physician's recommendation for exercise would help them get more involved in regular exercise (3).

Clearly, mechanisms are needed to aid physicians in developing appropriate exercise programs for their patients (4,5). However, physical activity assessment and counseling is not yet routine practice for most primary care providers. Two recent national surveys found that primary care physicians provided exercise counseling to less than 30 percent of their sedentary patients (6). Barriers to exercise counseling cited by physicians

include lack of experience in counseling patients, time constraints, absence of insurance reimbursements, lack of education related to the medical aspects of exercise, and the unavailability of standard formats for assessing and prescribing exercise (7). A standardized assessment and counseling protocol for physical activity promotion in the clinical setting would improve physician efforts to provide exercise counseling as recommended by several studies (6,8,9). The Surgeon General's Workshop on Health Promotion and Aging (1988) recommended that health care providers use physical activity assessment, prescription, and follow-up protocols for increasing physical activity among the elderly during regular physical examinations and medical visits (10). One of the objectives in *Healthy People Year 2000* calls for at least 50 percent of primary care providers to routinely assess and counsel their patients regarding the frequency, duration, type, and intensity of each patient's physical activity practices (6). Because of the potential benefit, the U.S. Preventive Services Task Force recommends that clinicians counsel all patients to engage in a program of regular physical activity tailored to their health status and personal lifestyle (11). One way to interact with patients in a cost-effective manner is through the use of computer technologies (12). While computer use by older adults at this time is lower than with other age groups, this is likely to change with the increased popularity of computers. The purpose of this study, therefore, was to develop a computerized exercise expert ystem (CEES) that creates a standardized assessment and counseling protocol providing individualized exercise plans for older adults.

While it is not the aim of the CEES to replace the interaction with a real human (i.e., the physician or other health practitioner), an expert system such as this one could serve as a tool to gather pertinent information and have it organized in order to facilitate the patient's interaction with the practitioner. Additionally, the premise behind an "expert" system is to provide expert advice. Therefore, if a practitioner is not experienced in the art and science of exercise prescription writing, the CEES could bridge that gap. **Figure 1** illustrates how the CEES was developed using several different steps. For instance, in **Figure 1**, actions are represented by the circles that created the different components of the CEES as shown by the squares.

The CEES customizes exercise plans based on the older individual's health status, clinical factors, and exercise determinants or psychosocial factors that influences their exercise behavior. The CEES provides a standard format for assessing and prescribing the most suitable exercise activities based on the older adult's individual profile. In fact, research strongly suggests that if an individual's profile of determinants matches the characteristics of an exercise program, the greater the likelihood that the individual will begin and continue the program (8). Therefore, exercise plans created from the CEES are designed to match the older adults' profiles on key determinants to provide a customized exercise plan.

This project directly addresses the mission of the Atlanta Rehab R&D Center, which is to improve the function, independence, and quality of life of veterans who are aging and acquiring disabilities as they age. Thus, this study is directly related to the VA patient-care mission of maximizing the practice of preventive measures and health maintenance for older veterans.

METHODOLOGY

Project Staff and Experts

The study was approved by the Human Investigations Committee of Emory University School of Medicine for studies involving human subjects. A written informed consent was obtained from all subjects. The principal investigator (PI) served as the facilitator, forming a multidisciplinary team. The PI identified four key groups to provide theoretical and applied knowledge of exercise and aging for the project. The PI selected the first group, made up of the project team members with expertise in psychometry, exercise physiology, and computer sciences (**Table 1**; **Appendix 1**). The team had experience with test construction, exercise prescriptions, exercise strategies, information systems design, and human-computer interface design. The PI identified 3 groups consisting of 4 local, 14 national, and 1 international expert (n=19; age range 41–70 years; mean age=49.5 years) who were selected to participate in this project to achieve balance in the areas of medicine, exercise physiology, health promotion, exercise psychology, and gerontology (**Table 1**; **Appendix 1**). The panel of experts was chosen based on several criteria: 1) they have conducted research studies in exercise; 2) they have published extensively in geriatric research; and/or 3) they have clinical experience with the geriatric population. All experts held postgraduate degrees, and 50 percent were females. The experts communicated by telephone, email, mail, and when attending the expert meetings and the two-day workshop.

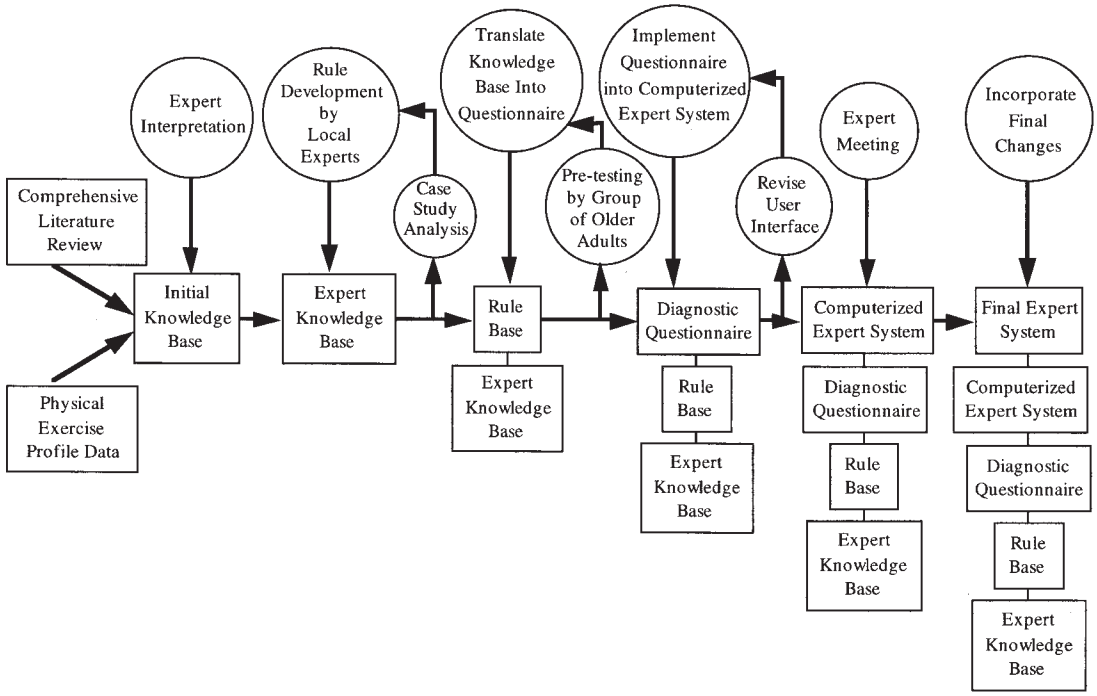

Figure 1. Exercise Expert System evolved by using an iterative process.

Table 1.
Description of collaborators

Project Expert	**N=6**	
No.	**Specialty**	**Degree**
1	Psychometry	M.Ed.
3	Expert System Design	2 M.S., Ph.D.
3	Exercise Physiology	2 B.S., 1 M.S.
Local Experts	**N=14**	
No.	**Specialty**	**Degree**
2	Physician	M.D.
1	Professor of Nursing	Ph.D.
1	Physical Therapist	Sc.D.
National Experts	**N=14**	
No.	**Specialty**	**Degree**
2	Nursing	M.S., Ph.D.
2	Gerontologist	Ph.D.
4	Physician	M.D.
1	Exercise Psychologist	Ph.D.
2	Exercise Physiologist	Ph.D.
1	Physical Activity Epidemiologist	Ph.D.
1	Physical Therapist	Ph.D.
International Experts	**N=1**	
No.	**Specialty**	**Degree**
1	Physical Therapist	Ph.D.

Steps in Developing the Computerized Expert System

1) Review of the Knowledge Base

The experts reviewed a knowledge base that consisted of information merged from research findings that used the Physical Exercise Profile (PEP) questionnaire (13) and from an extensive literature review of over 60 published studies specifically relating to determinants that influenced elders' exercise behavior. The experts critiqued the knowledge base for organizational structure and completeness. The experts examined the determinants within the categories of personal characteristics, knowledge, attitudes and beliefs; psychological/behavioral attributes; activity characteristics; and environmental characteristics. The knowledge base was updated to represent a detailed and comprehensive document of 29 determinants that influence exercise initiation and adherence in older adults.

Next, the experts ranked the determinants according to their priority in motivating older adults to initiate and adhere to exercise. Each expert independently prioritized the 29 determinants using a scale of 1 to 10, with 10 being most important. In this study, the initiation phase was defined as the first 6 months of starting a new exercise program, while the adherence phase was defined as continuing the exercise routine after the initial 6-month period.

2) Creation of the Rule Base

Rules were designed to define which exercise(s) was chosen, using a ranking system to rule in or out certain exercises based on the patient's responses from the PEP-R. Rules were then created to prescribe the exercise intensity, frequency, and duration for each exercise mode (aerobic, strength training, and flexibility exercises) for the individual. Furthermore, rules were developed to determine where the individual would most likely want to exercise (i.e., home, facility, or community park).

As part of the rule base, the project staff and experts compiled a pool of over 300 strategies to enhance the patient's initiation and adherence to the exercise prescription. These strategies were based on empirical knowledge from the experts' own dealings with older adults and gleaned from published research articles and abstracts. Depending on the patient's response to each question, specific strategies were printed out. Each presented tailored recommendations for that individual.

3) Expansion of the Questionnaires

An important component of this project was the refinement and expansion of the original PEP (13). The original PEP assessed seven determinants of exercise behavior and as part of this project, it was expanded into the PEP-R to measure 29 exercise determinants. The PEP-R prototype was administered by hard copy to a sample of older adults comprised of a group of exercisers (n=36) and a group of non-exercisers (n=17). The older adults were representative of various socioeconomic, health, and fitness levels. Exercise status was defined by whether they had an exercise routine during the month prior to answering the questionnaire. Each participant completed the PEP-R prototype independently and then completed its evaluation. This evaluation screened for potential problems such as low discriminability (i.e., all responses identical on an item), ambiguous or poorly worded questions (i.e., a preponderance of inappropriate responses on an item), and areas of sensitivity (i.e., questions that respondents refuse to answer). Consideration was also given to the length of time required to complete the questionnaire.

Additionally, two other questionnaires were developed for the expert system. The Exercise Program Considerations for Health Practitioners (EPCHP) was developed for health practitioners to determine the medical eligibility of their clients when using the CEES. The Prescreening Inventory (PSI) was developed to obtain personal medical history directly from the patient.

4) Verification of the Documents

By using an iterative process, 12 bi-monthly meetings of the local experts and project team were conducted to examine all documents, including the rule base, PEP-R, EPCHP, and PSI. In order to facilitate this process, seven case studies using real and fictitious older adults were introduced, and documents were created for each case. The specific circumstances of these cases were discussed in relation to the determinants, appropriate exercise prescriptions, and associated recommended strategies. These cases were sent out to the international and national experts for their review. The project staff amended all documents for the case studies were, to ensure that the exercise plans were acceptable based on expert opinion. The process was repeated using 10 more case studies. The PEP-R, the EPCHP, the PSI, and the associated rules/strategies were finalized based on the experts' and older adults' opinions and then implemented into the CEES.

Evaluation of the CEES at the National Workshop

A national workshop was held to evaluate the CEES. Twelve experts in the fields of nursing, medicine, exercise physiology, health promotion, exercise psychology, and gerontology attended the national workshop along

with 10 project staff members (**Table 2**; **Appendix 2**). A facilitator with a Ph.D. in Aging Psychology led the two-day workshop using an extensive agenda. As an unbiased moderator, she ensured that all of the experts were able to discuss their different viewpoints and suggestions throughout the two-day meeting, and she kept the workshop participants on task.

As part of the national workshop, data were collected to determine reliability of the CEES at a minimum level of 0.70. Inter-rater reliability was examined by evaluating 20 cases for percent agreement between the 22 experts for the exercise prescriptions, which include the exercise mode, frequency, intensity, and duration. The 22 participants were first divided into 4 groups, and each group received 5 sample cases. Group members individually developed recommendations for an exercise prescription using the following: mode of exercise (aerobic, strength, and flexibility), frequency of exercise, duration of each exercise session, and intensity of mode. The raters' prescriptions were then compared with their group members' prescriptions. The experts within each group reached a decision on the appropriate exercise prescription for each of their five cases.

In addition, the evaluation of the CEES interface was conducted by examining the average percent agreement between the experts' critiques of the EPCHP, the PSI, and the PEP-R Questionnaire. In addition to these three questionnaires, four additional reports produced by the system were critiqued: 1) Strategies; 2) Practitioner's Report; 3) Client's Report; and 4) Fun Facts. The experts rated the questionnaires and reports on a scale of 1 to 3 with 3 being excellent on the following seven attributes: 1) font type/size, color, 2) yes/no blocks, 3) check boxes, 4) wording 5) user-friendliness, 6) proper information gathered, and 7) length.

During the national workshop, data were collected for the validity of the CEES. Criterion validity was examined between the raters and the expert system by two methods: 1) Pearson correlations and 2) percent agreement. The expert system was considered to be the gold standard for creating the exercise prescriptions because its rules were based on experts' advice and guidelines published by the American College of Sports Position Stand (14). The groups compared the prescriptions that they designed for the five cases to the expert system's prescriptions, and any discrepancies were cross-examined until consensus was reached among the experts concerning the appropriateness of the exercise plan developed for each case. Content validity was determined having the experts review the early to late stages of the three instruments, the EPCHP, the PSI, and the PEP-R.

Each expert also entered 1–2 case studies of actual or hypothetical older adults into the expert system to see if the system met their expectations from their own data input. Each of the case studies including the strategies and prescriptions was reviewed by the experts. Any areas of disagreement between the experts regarding the exercise prescriptions were used for expansion and/or refinement of the questionnaires, strategies, rules, and user interface.

Table 2.
Description of collaborators

No.	Specialty	Attendee	Degree
1	Aging Psychology	Project staff	Ph.D.
2	Exercise Psychology	Project staff	M.Ed., Ph.D.
4	Expert System Design	Project staff	1 B.A., 2 M.S., 1 Ph.D.
3	Exercise Physiology	Project staff	2 B.S., 1 M.S.
2	Physician	Local expert	M.D.
1	Professor of Nursing	Local expert	Ph.D.
1	Physical Therapist	Local expert	Sc.D.
1	Nursing	National expert	M.S.
1	Gerontologist	National expert	Ph.D.
3	Physician	National expert	M.D.
1	Physical Activity Epidemiologist	National expert	Ph.D., M.P.H.
1	Physical Education	National expert	B.S.
1	Exercise Psychology	National expert	Ph.D.

RESULTS

Determinant Ratings

The experts ranked in order what they believed to be the most important exercise determinants when designing an exercise plan for older adults. When examining the 29 determinants for the highest rated initiation determinant, *convenience of the exercise routine* (mean=8.8; SD=1.4), *social support* (mean=8.6; SD=1.4), *self efficacy* (mean=8.4; SD=2.3), *biomedical status* (mean=8.3; SD=1.8) and *intent to be physically active* (mean=8.2; SD=1.7), respectively, were the most important factors to consider when trying to get the older individual to start an exercise program. When examining what determinants were most important for the adherence phase of exercise, *convenience of the exercise routine* (mean=8.8; SD=1.1), *social support* (mean=8.8; SD=1.4), and *enjoyment* (mean=8.8; SD=1.0) were equally important, followed by *biomedical status* (mean=8.4; SD=2.0), and *self motivation* (mean=8.3; SD=2.1). In fact, 3 of the 29 determinants were believed to be significant for both the initiation and adherence phases: *convenience of the routine*, *social support*, and *biomedical status*.

PEP-R Evaluation by Older Adults

Eighty-seven percent of the respondents felt that the questionnaire gathered all the information necessary to fully describe their exercise habits. Seventy percent responded that there were no additional questions needed to find out more information about their exercise habits. Further, 66 percent said that all of the multiple-choice responses were appropriate for each question. About half of the respondents (52 percent) indicated that the questionnaire was too long. The questionnaire took approximately 35 minutes to complete by the older adults. The longest amount of time the subjects believed necessary to fully describe their exercise habits was 26 minutes. The PEP-R was subsequently shortened by editing or deleting several of the questions. We did not re-administer the hard copy after that to determine if it was acceptable in terms of time. This is a limitation of this particular task within the project. Instead, we gathered their feedback to adapt the hard copy and then to implement the questionnaire into the expert system.

National Workshop

The two-day workshop involving the experts from different disciplines was an intensive and worthwhile endeavor. The experts worked independently and in groups throughout the 2 days using a well-organized agenda. They strengthened the expert system because of their knowledge and experience in exercise and working with older adults. The experts commented upon how they appreciated the experience of seeing how their reviews on hard copies via mail and by expert meetings and conference calls evolved into this computerized exercise expert system. Both the local and national experts were consulted two more times after the workshop to provide final reviews of the changes that were made based on the workshop.

Inter-rater Reliability

Overall, there was 80 percent agreement between the raters across all four components for inter-rater reliability (**Table 3**). When examining the 20 cases for inter-rater reliability of the exercise mode (aerobic and flexibility), the agreement was 89 percent between the experts. When examining the inter-rater reliability for the exercise frequency across all three modes, the agreement between the raters ranged from 84 percent to 66 percent with an average inter-rater reliability of 72 percent (**Table 3**). For flexibility and strength training, both showed 66 percent agreement between the raters. Some of the experts were recommending the clients do stretching for a shorter duration than other experts recommended. After some discussion at the workshop, the experts agreed that stretching could easily fit into the warm-up/cool-down of the person's workout session without making the routine too long. There was a change from 66 percent to 100 percent agreement between the raters that they will recommend people stretch for a minimum of 20–30 minutes using the most recent ACSM

Table 3.
Inter-rater reliability between experts (cases = 20)

Domains	Percent Agreement
aerobic mode	91%
flexibility mode	86%
strength training mode	n/a
aerobic frequency	84%
flexibility frequency	66%
strength training frequency	66%
aerobic duration	81%
flexibility duration	83%
strength training duration	80%
aerobic intensity	78%
flexibility intensity	86%
strength training intensity	71%
Overall inter-rater reliability	**80%**

Position Stand (14) instead of using the old 1990 ACSM (15) guidelines, which recommended at least 10 minutes. For strength training frequencies, some of the experts were recommending 2 days a week as a minimum, whereas other experts were prescribing it at a minimum of 3 days a week. After further discussion, the experts reached a consensus that strength training could be done two to three times a week, which is in line with the most recent ACSM Position Stand (15). As a result of this consensus-building process, the inter-rater reliability for strength training, therefore, changed from 66 percent to 100 percent. When examining the duration of the three modes, the agreement between the raters ranged from 81 percent to 83 percent, with an average inter-rater reliability of 81 percent. When examining the intensity of the three modes, percent agreement ranged from 86 percent to 71 percent with an average inter-rater reliability of 7 percent.

Validity

When evaluating how well the domains matched between the experts and the CEES, Pearson correlations were analyzed (**Table 4**). The Pearson correlations for the 11 domains ranged from −0.016 to 1.0 with duration of flexibility being the lowest. The highest correlations were the aerobic and flexibility intensity, both showing a correlation of 1.0 with a significance level of p=0.000. All of the domains were significant at the 0.05 level, excluding the duration of flexibility. The average correlation of the 11 domains was 0.70, which demonstrated adequate criterion validity, as correlations over 0.50 are considered strong in magnitude (16).

Table 4.
Criterion validity using Pearson correlations (cases = 20)

Domains	Pearson's r	Significant Level
Aerobic mode	.985	*.000
Aerobic frequency	.535	*.015
Aerobic duration	.678	*.001
Aerobic intensity	1.000	*.000
Strength frequency	.791	*.000
Strength duration	.791	*.000
Strength intensity	.804	*.000
Flexibility mode	.454	*.051
Flexibility frequency	.637	*.003
Flexibility duration	-.016	.947
Flexibility intensity	1.000	*.000
Average correlation	**.70**	

* = significant at the .05 level or less

Another method for establishing criterion validity was evaluated by determining how much the raters agreed with the CEES on the different exercise prescriptions (**Table 5**). The percent agreement between the raters and the CEES for the 11 domains ranged from 100 percent to 58 percent with duration of flexibility being the lowest. The average percent agreement of the 11 domains was 85 percent, which established adequate criterion validity. Content validity was established in the early to conclusive phases of the EHCP, PSI, and PEP-R, by allowing experts to ascertain that all domains assessed by the instruments were adequately measuring and representing the content presented (17).

Table 5.
Criterion validity of the CEES using percent agreement (cases = 20)

Aerobic Component	Percent of Agreement with CEES
mode	95%
frequency	80%
time	90%
intensity	70%
Strength Component	
frequency	84%
time	84%
intensity	90%
Flexibility Component	
mode	75%
frequency	85%
time	58%
intensity	100%
Overall Criterion Validity	**85%**

The critique of the expert system and its generated reports were evaluated by percent agreement between the experts (**Table 6**). The percent of agreement ranged from 100 percent to 74 percent. The Practitioner's Report, Client's Report, and Fun Facts showed 100 percent agreement that all seven attributes were excellent. The PSI received the next highest agreement with 93 percent agreeing that it was excellent. The Strategies Report showed 87 percent that it was excellent, with length being the main concern. The EPCHP Questionnaire showed 86 percent agreement that it was excellent, with the wording being the main concern. Seventy-four percent of the

Table 6.
Critique of the expert system and its generated reports

Generated Reports	Percent of agreement between experts
EPCHP	86%
PreScreening	93%
PEP-R	74%
Strategies	87%
Practitioner's Report	100%
Client's Report	100%
Fun Facts	100%
User-Friendliness of CEES	100%

experts believed that the PEP-R was excellent, with length again being the main concern. When the attributes were not rated as excellent, they were rated as good. All of the experts (100 percent) rated the CEES as excellent for user friendliness.

DISCUSSION

The final design of the CEES utilized the results from the national workshop. The expert system uses a Microsoft Access database programming software for the database development. The computer requirements are a basic IBM PC- compatible computer system with Office 97 Windows program and a printer. The CEES is composed of three questionnaires, the first one being the EPHCP. The health practitioner (such as the personal physician or nurse practitioner) completes this questionnaire. This assessment documents any absolute or relative contraindications the patient has regarding exercise. It is used as a guide to determine if the patient is appropriate to participate in an exercise plan prescribed by the CEES.

The second report is a PSI, answered by the patient based on his or her own personal medical history. Items included are those medical conditions that might influence the exercise prescription. The third document is the PEP-R diagnostic questionnaire, and these responses along with the PSI are used in creating the individualized exercise plans. Information and preferences about the determinants are gathered from the patient by multiple menu presentations, providing "user-friendly" screens. To finish the entire software package, takes an average of approximately 12 to 79 minutes (with an average time of 32.58 minutes) to complete, depending on the individual (18).

After these three questionnaires are completed by the practitioner/patient, five reports are generated: Client's Report; 2) Practitioner's Report; 3) Strategies; 4) Fun Facts to Know; and 5) Exercise Prescription. The Client's Report is created for each older individual describing his or her PEP. Included in this report are the current month and past year exercise level for aerobic, muscular strength and endurance, and flexibility exercises. The body mass index of the individual is computed using height and body weight. Behavioral characteristics that also influence the person's exercise behavior are provided such as: perceived readiness, exercise knowledge, perceived health, self-motivation, self-efficacy, and intent to be physically active. All of these physiological and behavioral components are scored and placed in a low, medium, or high range. In addition, an explanation of what it means to be in that range is included on the Client's Report. An individualized exercise plan with suggested strategy recommendations along with a Fun Facts to Know Report is also created for the individual. The Practitioner's Report is created for the health professional, and includes an outlined summary of the client's information along with duplicated information from the Client's Report. Three additional scale scores are provided on the Practitioner's Report that are not included on the Client's Report: body image, depression, and anxiety scores. If depression or anxiety is in the moderate to severe range, it is suggested that the health practitioner recommend that the client have a medical evaluation to address this. Likewise, if the person's body image score is in the moderate to severe range, specific strategies are assigned to the practitioner so he or she can help the client gain confidence in this area.

The experts pointed out that for aerobic exercise, there were several to choose from such as walking, jogging, or swimming, so strength training exercise needed more choices. Based on the consensus of the experts, more strength training exercises were given to the CEES: 1) calisthenics, light weights, or elastic bands; 2) machine or free weights; or 3) Tai Chi. In fact, much discussion was held about placing Tai Chi into the strength category and not being left in the flexibility category. A consensus was reached among the experts that Tai Chi impacts strength more than flexibility. Researchers in the geriatric field have found Tai Chi can help maintain strength gains (19,20). The health practitioners now have more strength options to select from that might better match the needs of their clients.

Future Directions

The CEES was tested with 34 community dwelling older adults (mean age=70.52 years; 50 percent females) for practicality and acceptability (18). On a scale of 1 to 5, the system was ranked 4.53 for ease of use. For acceptability of the exercise prescription, the average score was 22.5 on a scale of 6 to 24. Sixty percent of the participants found it important for health providers to spend more time doing exercise counseling. As a result of this project, one paper was presented to the Gerontological Society of America in November of 1999 and another presentation was given at the Second VA Rehabilitation R&D Meeting in February of 2000 (18,21).

Currently, a pilot study is underway to evaluate the CEES as a means of assessing exercise behaviors and providing exercise counseling to a sample of older adults. The experimental group receives a *tailored* exercise prescription by the CEES and the comparison subjects receive a generic exercise prescription. The exercise physiologist spends the same amount of time with both groups in her exercise consult. We are determining if the experimental-group members increase in their level of exercise activity as compared to the comparison group. We are also evaluating the time necessary to complete the CEES assessment and exercise consult in order to later streamline and shorten the entire visit. In the future, it would be ideal if more health providers could allow more time for exercise assessments and consults to encourage and promote physical activity because of the positive benefits associated with exercise adoption. The CEES can be shortened to adapt to today's environment, but it is our intent that research such as this will change the way exercise counseling is conducted. We need to spend more time with our patients in promoting preventive types of healthful behaviors in hopes of spending less time with them as a result of their illnesses.

To determine if there were any existing expert systems similar to the CEES, a law firm conducted a computer database search including articles appearing in academic and industry journals, U.S. patents, and published PCT patent applications. Based on their examination of the materials identified from this search, it was their opinion that none of these documents have designed a system similar to the CEES. The search identified three U.S. patents that design individualized exercise regimens. The Khavari patent is a computer program that creates individualized exercise protocols for individuals recovering from various cardiovascular and/or pulmonary diseases (22). The Khavari patent appears to be restricted to rehabilitation (regardless of age) rather than fitness of older persons and does not use psycho-social variables that influence exercise initiation and adherence when developing the exercise plan. The health provider obtains health information from a patient including age, sex, heart rate, and blood pressure. This information is entered into a computer to help create an individualized exercise protocol for the individual. The computer program compares the health information for the current patent with the data records in the database for identifying data records containing similar health information. The computer program then creates an exercise protocol for the current patient based on previous exercise protocols in the identified data records.

The Brown patent was the second one found in the search (23). It is a fitness-monitoring system using a personal exercise-monitoring device that is pre-programmed with data to guide the patient in a appropriate exercise session. The monitoring device is connected to a central computer system for downloading data recorded during the exercise. The central computer has stored information that can compare the information that is sent by the monitoring device to provide feedback to the user. The variables utilized in the system appear to be focused exclusively on fitness parameters such as heart rate, blood pressure, and percent body fat, regardless of the age of the user. This patent does not use any exercise determinants to help formulate the exercise prescription for the elder.

The Roth patent is the third one identified in the search that creates a user database where medical information and age are inputted (24). The Roth system uses a compact portable battery-powered computerized digital training assistant (DTA). Each DTA is programmed with the user's exercise routine calculated for the specific workout session. The DTA unit interactively instructs the user on the sequence and exercises to be performed and the preferred performance criterions. A keypad interface to change the criterions is provided to permit recording of the actual exercises performed. The resulting exercise information is downloaded back to the system, where it becomes a permanent part of the user's exercise history database file. The file's data will be used in the calculation of the next session's performance parameters. This patent does not consider exercise regimens for age-specific or psychosocial factors as does the CEES.

The review of the results of the computer search suggests that there is not another exercise expert system available that uses psychosocial factors that affect older

adults starting and/or maintaining an exercise routine. The search is limited, however, as it was based upon a review of computer databases, which may be incomplete. For instance, only abstracts of those articles that included abstracts in the computer databases were searched. Furthermore, as pending U.S. patent applications are maintained in secrecy by the U.S. Patent and Trademark office, the most relevant one may be unavailable to review. However, it appears from this computer database search that the CEES is a unique expert system for developing exercise plans based on specific determinants that influence exercise behavior.

SUMMARY AND CONCLUSIONS

This project provided a much better understanding of what determinants are important to exercise initiation and adherence for older adults. The experts identified convenience of the routine, social support, and biomedical status, respectively, as most crucial when designing an exercise plan for this subpopulation. The inclusion of the three questionnaires by the CEES was validated by the consensus of local and national experts in the fields of geriatric medicine, exercise physiology, and exercise psychology. The output of the expert system includes both a client's report and a practitioner's report. The client's report consists of a customized exercise prescription, recommended strategies, and an exercise information sheet. The practitioner's report consists of the client's exercise prescription, summary of determinants, and exercise preferences. Based on the individual's exercise determinants, the tailored exercise plan should increase the likelihood that older adults will initiate and adhere to exercise.

Health care providers have a unique opportunity to favorably impact lifestyle choices during the client's routine medical visit. Use of the CEES could help facilitate the health care providers' skill and effectiveness in providing a crucial aspect of primary care prevention through exercise. This system is a quick and useful software package that has standardized questions for the health practitioner to administer to his or her clients, and the result is a customized exercise plan based on that individual's personal profile. The CEES can later be expanded to include recommendations specific to other subpopulations, including those with physical disabilities (i.e., Parkinson's Disease or arthritis) and chronic illnesses such as heart and pulmonary disease. By utilizing the CEES within health care settings, the potential for making exercise prescriptions available to older individuals, and in this way, facilitating initiation and adherence to custom-tailored exercise, is enormous.

APPENDICES

Appendix 1. List of Collaborators

Project Staff

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Local Experts

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Robert A. Zorowitz, MD, FACP Medical Director of Geriatrics Services, DeKalb Regional Healthcare System, Decatur, GA.

National Experts

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Steven N. Blair, PED, Director of Epidemiology and Clinical Applications at the Cooper Institute for Aerobics Research, Dallas, TX.

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Barbara J. Fletcher, RN, MN, FAAN, Clinical Associate Professor, University of North Florida, College of Health, Department of Nursing.

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Edward McAuley, PhD, Professor of Exercise Psychology, Department of Kinesiology, University of Illinois at Urbana-Champaign.
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Scott Sherman, MD, MPH, Assistant Professor Medicine, UCLA/San Fernando Valley Program. Chief, PACE Research, Evaluation, and Faculty Development, Sepulveda, CA VA Medical Center.
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Appendix 2. National Workshop Attendees
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